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ANNOTATED BIBLIOGRAPHY OF THE PALLID KANGAROO MOUSE (Microdipodops pallidus)

by

David Fletcher
California State University
Fullerton, California

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Riverside, California 92507

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Microdipodops pallidus, Merriam

An annotated bibliograpy prepared
for the Bureau of Land Management
by Dave Fletcher, Calif. State University
at Fullerton.

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A. Taxons

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subphylum: Vertebrata

superclass: Tetrapoda

Class: Mammalia

Order: Rodentia

suborder: Myomorpha

superfamily: Geomyidea

Family: Heteromyidae

subfamily: Perognathinae

Genus: Microdipodops

Species: pallidus, Merriam 1901

subspecies: M.p. ammophilus, Hall 1941

M.p. pallidus, Merriam 1901

M.p. purus, Hall 1941

M.p. ruficollaris, Hall 1941

(Hall, Kelson 1959)

B. Category Description

1. Order Rodentia

a. Largest mammalian order consisting of 34 families, 354 genera, and approximately 1685 species.
b. Upper and lower jaw each bear a single pair of persistently growing incisors.
c. Dental formula seldom exceeds 1/1, 0/0, 2/1, 3/3 = 22, and a diastema is always present between the incisors and the premolars. The incisors and canines are always 1/1, 0/0.
d. Glenoid fossa of the squamosal is elongate, allowing anteroposterior and rotary jaw action. The mandibular symphysis has sufficient "give" in many species to enable the transverse mandibular muscles to pull the ventral borders of the rami together and spread the tips of the incisors. (After Vaughan, 1972)

2. Suborder Myomorpha

a. The masseter superficialis muscle originates on the rostrum, and the anterior part of the masseter lateralis originates on the anterior extension of the zygomatic arch.
b. The masseter medialis muscle originates partly on the rostrum and passes through the narrow infraorbital foramen. (After Rinker, 1954)

3. Superfamily Geomyoidea

a. Two families; Geomyidae and Heteromyidae
b. External cheek pouches present.

4. Family Heteromyidae

a. Five genera, Perognathus, Microdipodops, Dipodomys, Liomys, Heteromys and approximately 70 species.
b. Geological range of the family is the lower Oligocene to Recent in North America and the Recent in South America.
c. The thin skull is papery in consistency and is not strongly modified for an underground life. Zygomatic arches are slender and thread-like.
d. The long narrow infraorbital canal is sunken within the skull to protect it against muscle pressure, and its opening is anterior to the zygomatic arch and lateral to the rostrum.
e. The members of the genera Perognathus, Liomys, and Heteromys travel on all four limbs, usually assuming a bipedal position while foraging, but the members of the genera Dipodomys and Microdipodops typically progress only on the hind limbs, with the tail serving as a balancing organ in locomotion and as a prop when standing.
f. Life span in nature may be only a few months because of predators. Natural enemies include coyotes, weasels, badgers, skunks, rattlesnakes, owls, and hawks.
g. Diet consists mainly of seeds and vegetation but also includes insects and other invertebrates.
h. Members of the family shelter in self-constructed burrows under bushes, trees and logs.

i. Members of the family generally remain in their burrows during cold or wet weather, and pocket mice (Perognathus), in particular, may become quite torpid during inclement weather.
j. Some forms derive all their water from the solid foods they eat and from conversion of some of the food into water within the body. Other species drink very little water. In some species the excretory systems are somewhat modified in order to extract the maximum liquid from the food they eat. (After Walker, 1975)

5. Genus Microdipodops: Kangaroo mice

a. Two species: Microdipodops megacephalus and Microdipodops pallidus.
b. Physical characteristics:
   1. Length of head and body is 66 to 77 mm.
   2. Tail is 64 to 103 mm. in length.
   3. Weight is 10.2 to 16.8 grams.
   4. In M. megacephalus the upper parts are brownish to grayish black; the under parts are pale grayish to white, and the terminal end of the tail is blackish. In M. pallidus the upper parts are pale creamy buff; the under parts are pure white, and the tail does not have the blackish coloration.
   5. Pelage is fairly long, silky, and lax; the tail is not crested or penciled. Fat is stored in the tail and is used as a source of energy during dormancy.
   6. A large head has developed due to the inflation of the audital bullae into paper-thin capsules that encroach onto the upper portion of the sides of the cranium.
   7. Hind feet are fringed at the sides with stiff hairs that increase the surface on the fine, soft, sand-like snowshoes; the undersurfaces of the hind feet are well furred. (After Walker, 1975)
   8. Auditory bullae more highly inflated than in any other heteromyid, reaching below level of grinding surface of cheek-teeth and in many individuals extending anteriorly beyond glenoid fossae; bullae meeting in a symphysis across ventral face of basisphenoid; antero-lateral face of zygomatic process of maxilla not much expanded, resulting in hamular process of lacrimal projecting free of maxilla.
   9. Dental formula: 1/1, 0/0, 1/1, 3/3; upper incisors grooved; cheek-teeth hypsodont but each with more than one root, except M 3/3; molars with H-pattern; P^4 as in Perognathus, P_4 with five or six cusps; cusps soon worn away with result that occlusal face of each cheek-tooth is an area of dentine completely surround by enamel.
   10. Manus long and slender; tibia and fibula fused throughout almost three-fifths of their length; cervical vertebrae mostly fused; caudal vertebrae lacking median ventral foramen. (After Hall, 1941)
   11. Locomotion is ricochetal (Hiatt, 1932).
c. Reproduction
   1. Young are born in burrows in May and June, the litter size is from one to seven, with an average of three to four. There may be two litters per year (Walker, 1975).
   2. Pregnant individuals found from 28 April to 22 September, and this has lead Hall to speculate kangaroo mice are polyestrous (Hall, 1941).
   3. Females found with perforated vaginal orifices in April and in July giving indication of two periods of estrus (O'Farrell, 1973).
   4. Reproduction is negatively affected by a lack of fall and winter precipitation and consequent germination of winter annuals (O'Farrell, 1973).

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   7. Hind feet are fringed at the sides with stiff hairs that increase the surface on the fine, soft, sand-like snowshoes; the undersurfaces of the hind feet are well furred. (After Walker, 1975)
   8. Auditory bullae more highly inflated than in any other heteromyid, reaching below level of grinding surface of cheek-teeth and in many individuals extending anteriorly beyond glenoid fossae; bullae meeting in a symphysis across ventral face of basisphenoid; antero-lateral face of zygomatic process of maxilla not much expanded, resulting in hamular process of lacrimal projecting free of maxilla.
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   10. Manus long and slender; tibia and fibula fused throughout almost three-fifths of their length; cervical vertebrae mostly fused; caudal vertebrae lacking median ventral foramen. (After Hall, 1941)
   11. Locomotion is ricochetal (Hiatt, 1932).
c. Reproduction
   1. Young are born in burrows in May and June, the litter size is from one to seven, with an average of three to four. There may be two litters per year (Walker, 1975).
   2. Pregnant individuals found from 28 April to 22 September, and this has lead Hall to speculate kangaroo mice are polyestrous (Hall, 1941).
   3. Females found with perforated vaginal orifices in April and in July giving indication of two periods of estrus (O'Farrell, 1973).
   4. Reproduction is negatively affected by a lack of fall and winter precipitation and consequent germination of winter annuals (O'Farrell, 1973).

d. Habits
   1. Nocturnal, often not coming out on brightly moon-lit nights (Hall, 1941).
   2. Greatest activity shown in the first two hours after sunset with varied and diminishing activity for the remainder of the night (O'Farrell, 1974).
   3. Microdipodops emerge from their burrows on nights when the temperature falls below freezing, but the mice apparently do not emerge when it is raining or snowing (Hall, 1941).
   4. O'Farrell (1973) found that in west-central Nevada M. megacephalus maintained a 2:1 adult sex ratio favoring males. Over a year no mortality was observed and a high degree of fidelity to a given locus was noted. He further determined that a small territory was maintained around the burrow and a relatively large home range was utilized that overlapped considerably with the home range of conspecifics. Seasonal changes in size of home range were noted. The mean yearly circular home range value for males was 6613 square meters, and for females 3932 square meters.
   5. O'Farrell (1973) determined the Perognathus longimembris inhibited the movements and activity of M. megacephalus. It was suggested that during the summer when these pocket mice were at peak activity, M. megacephalus probably shifted from a granivorous to an insectivorous feeding strategy. Hall and Linsdale (1929) determined that M. megacephalus was primarily a seed eater but mentioned the high incidence of insect matter in cheek pouches during the summer.
   6. Tunnels are simple, short, and unbranching (Hall and Linsdale, 1929). Nests and seed caches have been constructed in the laboratory (Blaustein, 1973).
   7. Activity has been noted from March through October. Microdipodops will spontaneously become dormant at ambient temperatures ranging at least from 5 to 26° C. and can readily be induced to hibernate over this range of temperatures by reduction of food for 24 hours or less (Bartholomew and MacMillen, 1961).

e. Genetics
   1. M. megacephalus: A male collected ¼ mile N. Fletcher, Mineral Co., Nevada -- The X Chromosome was a medium acrocentric and the Y chromosome was a small sub-telocentric (2N=40, FN=74). The autosomes were: six pairs of metacentrics, seven pairs of submetacentrics, five pairs of subtelocentrics, and one pair of small acrocentrics.
      M. pallidus: A male and female collected 15 miles N. Groom Baldy, Lincoln Co., Nevada -- The X chromosome was a medium acrocentric and the Y chromosome was a small subtelocentric (2N=42, FN=80). The autosomes were 16 pairs of metacentrics and submetacentrics, and four pairs of subtelocentrics.
   2. Hall (1946) presented evidence that hybridization occurs between M. megacephalus and M. pallidus in Penoyer Valley, N, of Groom Baldy, Lincoln Co., Nevada.

f. Distribution
   1. Kangaroo mice have been regarded as rare by most naturalists, and as late as 1927 there were probably no more than 150 specimens in all collections combined (Hall, 1941).
   2. Microdipodops are restricted to a distribution within the Great Basin of the United States. All the known occurrences are in the Upper Sonoran Life-zone characterized by sagebrush desert having been trapped altitudinally in elevation from 7600 feet in Monitor Valley, Nye Co., Nevada down to an elevation of 3900 feet at Smoke Creek in Washoe Co., Nevada.

3. Geographically specimens have been captured from Lake Co., Oregon southward to Inyo Co., California and Groom Lake in Lincoln Co., Nevada. In the west the mice are found on the east side of the Sierra Nevada in California in Modoc, Lassen, Plumas, Mono, and Inyo Counties eastward to the Dugway Proving Grounds in Tooele Co., Utah.
4. Although geographically dispersed over a wide area Microdipodops are restricted by edaphic factors. Generally the mice are found on fine, gravelly or sandy soils which accumulate in the desert valleys of the Great Basin. Hall (1941) found that M. megacephalus exists on gravelly soil, more often where gravel is mixed either with fine or coarse sand and that at some places the mice of this species seem to avoid fine sand. Hall also found that M.pallidus was always restricted to fine wind-blown sand. Ghiselin (1970), however, found a random distribution in M. pallidus on fine soil or gravel soil where it was sympatric with M. megacephalus.
5. Microdipodops have been trapped along with Dipodomys deserti and D. merriami in common numbers (Hall, 1946).

followed by brownish or buffy portion, and, on most longer hairs, tip of darker brown or black; under parts lighter, usually plumbeous in basal half and distally white, but in some subspecies white to

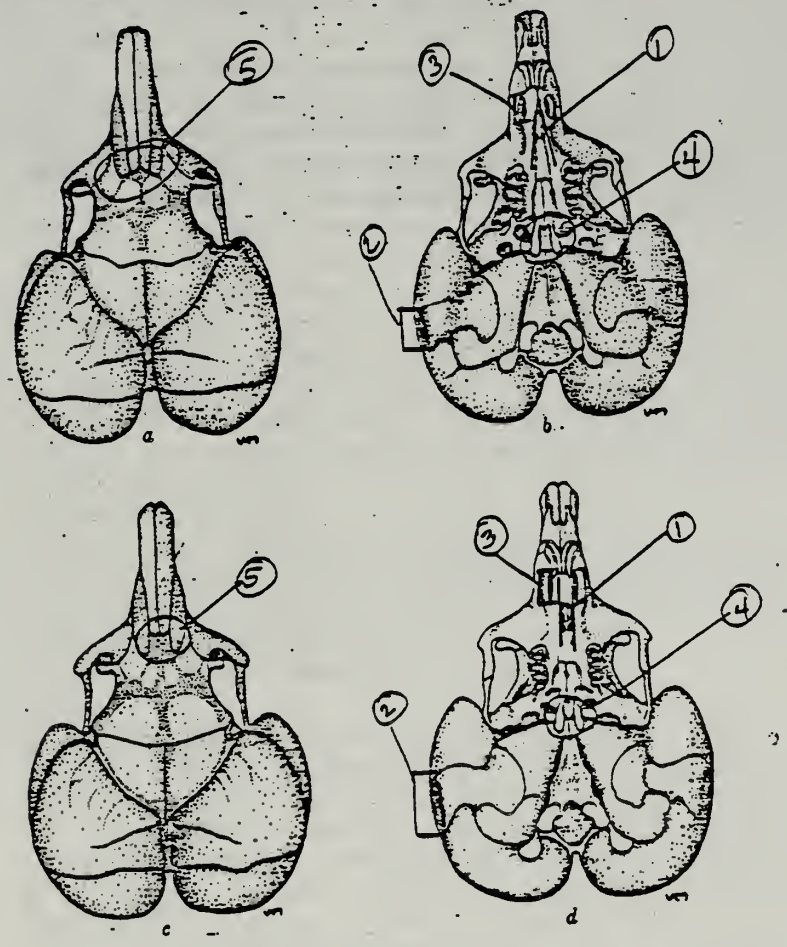

FIG. 46. *a*, *b*, Skull of *Microdipodops megacephalus megacephalus*, No. 70942, female, Winzell, Eureka County, Nevada. *a*, Dorsal view. *b*, Ventral view. *c*, *d*, Skull of *Microdipodops pallidus pallidus*, No. 59344, female, eight miles southeast of Blair, 4,500 feet, Esmeralda County, Nevada. *c*, Dorsal view. *d*, Ventral view. Note in *a* and *b*, in comparison with *c* and *d*, shortness of nasals relative to premaxillae, smaller auditory bullae, narrowness across maxillary arms of zygomata, and expansion posteriorly of incisive foramina. All $\times 1\frac{1}{4}$.

base, and in others plumbeous basally, then white and tipped with buffy; color of under parts extending over fore and hind legs, flanks and sides of head, but not encroaching as far upward as base of ear

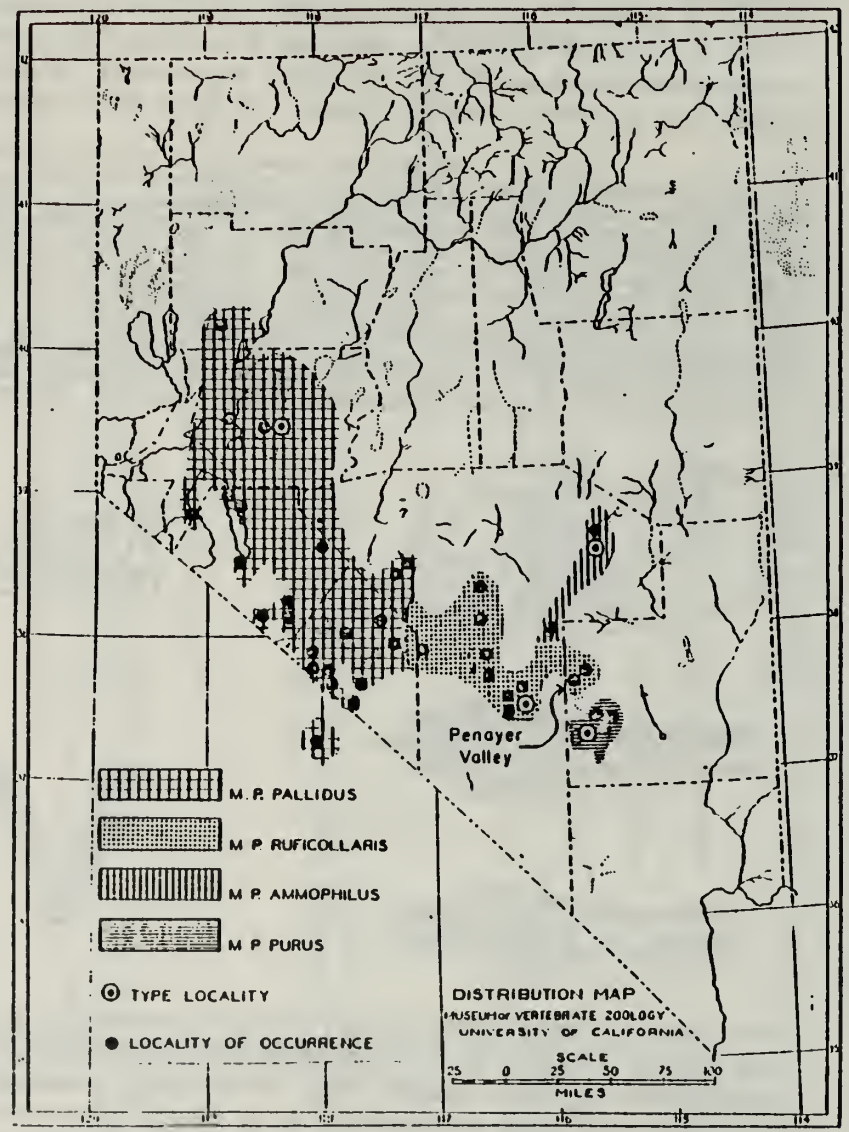

FIG. 52. Map showing geographic range of the subspecies of *Microdipodops pallidus*.

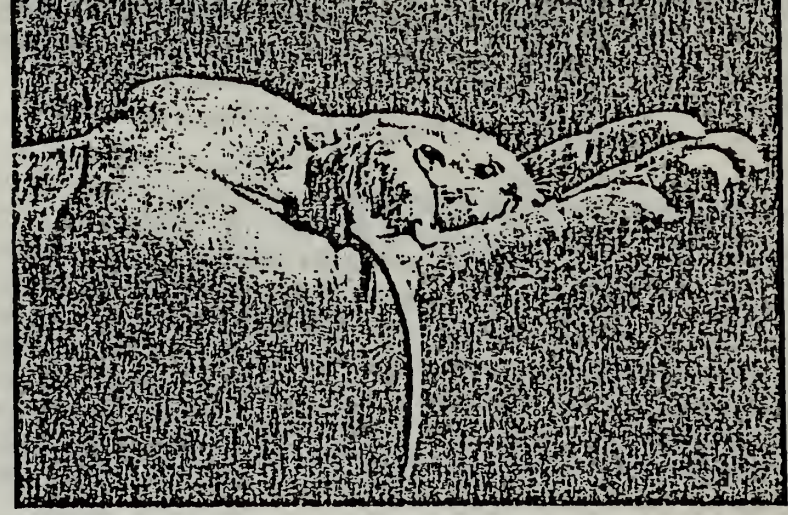

FIG. 1

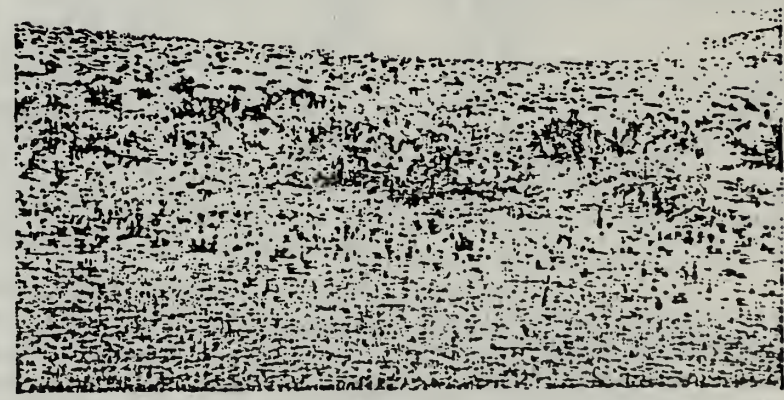

FIG. 2

FIG. 1. LIVE ADULT KANGAROO MOUSE (MICRODIPODOPS MEGACEPHALUS DICKEYI)

Note the large eye, small pinna of ear, long hind foot and long non-penicillate tail. Photograph taken June 14, 1927, by J. Dixon.

FIG. 2. TYPICAL HABITAT OF KANGAROO MOUSE

Fine, wind-blown sand with xerophytic shrubs, seven miles north of Arlemont, Esmeralda County, Nevada. Photograph taken June 4, 1927, by Miss Annie M. Alexander.

same as in *M. pallidus*, as is also the relation to one another of the posterior ends of the nasals and premaxillae. The hind foot in these western forms of *M. megacephalus* often is as long as in *M. pallidus*. Furthermore, these western forms of *megacephalus* are partial to fine wind-drifted sand, as is *M. pallidus*. At only one place in this western region, in Granite Spring Valley, 21 miles west

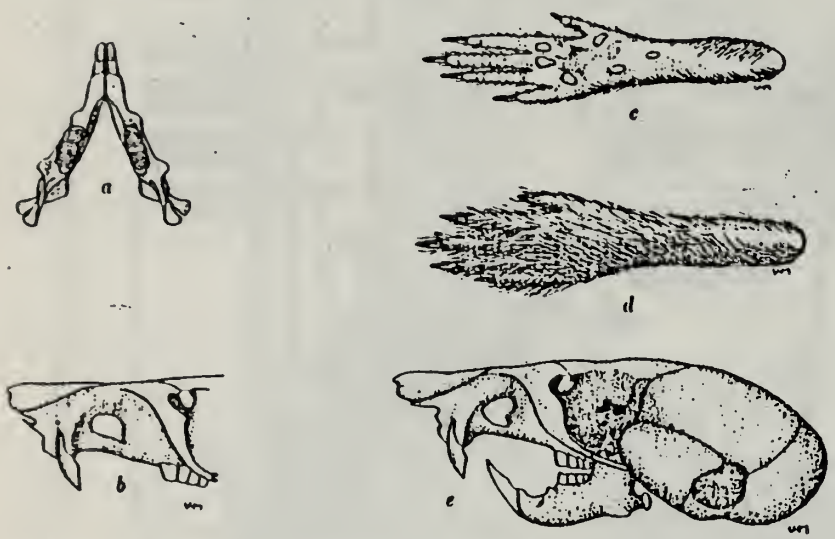

FIG. 47. *a*, *b*, *Microdipodops megacephalus megacephalus*, No. 70942, female, Winzell, Eureka County, Nevada. *a*, Occlusal view of teeth and lower jaw. *b*, View of left side of preorbital part of skull. *c*, *Perognathus parvus columbianus*, No. 86892, male, Ritzville, Adams County, Washington; plantar view of right hind foot. *d*, *Microdipodops pallidus pallidus*, No. 38757, male, seven miles north of Arlemont, 5,500 feet, Esmeralda County, Nevada; plantar view of right hind foot. *e*, *Microdipodops pallidus pallidus*, No. 59344, female, eight miles southeast of Blair, 4,500 feet, Esmeralda County, Nevada; view of left side of cranium and lower jaw. Note in *e*, in comparison with *b*, greater antero-posterior extent of lateral face of maxillary arm of zygoma, and less recurved upper incisors. *d* illustrates the hairiness of the sole of the hind foot of *Microdipodops* in comparison with the naked sole of the foot of *Perognathus*. All ×1½.

and two miles north of Lovelock, have we found the two species together. If there was a difference in type of soil occupied by the two we did not note it at this place. The two specimens of *M. megacephalus* are easily differentiated from the 11 *M. pallidus* by darker color and by lesser width across the auditory bullae. Otherwise, the 46 places of capture of these western races of *M. megacephalus* and the 19 places of capture of *M. pallidus*, west of Nye County, yielded mice of only a single kind at any one locality. Between the sandy soils supporting the two kinds of mice, some barrier of soil

This subspecies of *megacephalus* occurs in the same general area as *ruficollaris*, a race of the different species *pallidus*. The firmer soils were favored by *sabulonis* at each of the eleven places where the two species were taken in the same trap line. *M. pallidus* occupied the fine sands. It follows from the distribution of these two types of soils that *sabulonis* occurs on the sides of the valleys and has a more nearly continuous distribution than does *pallidus*, which occurs ordinarily in the lowest parts of the valleys. The

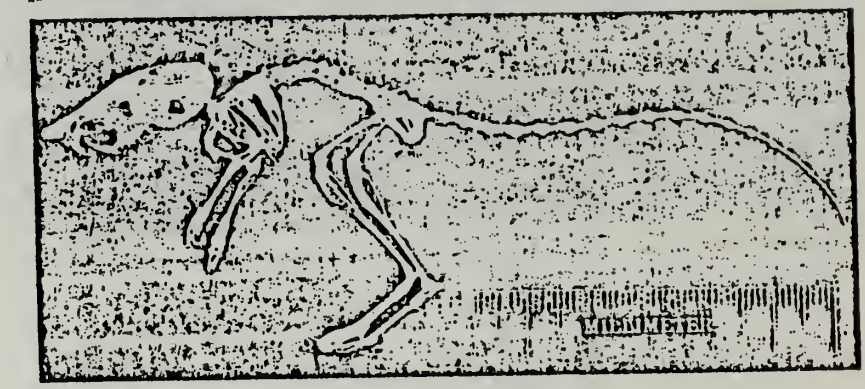

FIG. 50. Skeleton of *Microdipodops megacephalus sabulonis*, male, from nine miles west and three miles south of Tybo, 6,200 feet, Nye County, Nevada. ×4/5. Note the great length of the head relative to that of the body. Photograph by W. C. Matthews.

two kinds are easily distinguished by the color, and to me the difference is more easily perceivable in the live or freshly killed animals than in prepared study skins. The occurrence of three seeming hybrids among the 57 animals (34 *pallidus*, 20 *megacephalus*, and three "crosses") saved from Penoyer (Sand Spring) Valley makes further study at this place desirable, to learn for certain if two free-living species of wild mammals do here hybridize. If they do so, opportunity to study an unusual stage in the formation, or extinction by dilution, of a species would be afforded. The characters of the seeming hybrids are discussed in detail in the preceding section (p. 236) entitled "Speciation."

Specimens examined.—Total number 413, as follows:

NEVADA.—Esmeralda County: 13½ miles northwest of Goldfield, 4,850 feet, 22. Nye County: four miles southeast of Millett, 5,500 feet, 17; five miles southeast of Millett, 4; four miles south of Millett, 5,500 feet, 5; 11½ to 13 miles northeast of San Antonio, 5,700 to 6,700 feet, 26; 4¾ to six miles northeast of San Antonio, 5,650

II. Species Description

A. Original Description

Microdipodops pallidus Merriam 1901

Proc. Biol. Soc. Washington, 14:127, July 19, 1901. Type from 10 miles east of Stillwater, near sink of the Humbolt and Carson rivers, Churchill Co., Nevada. More restrictedly, according to Vernon Bailey (in litt.), the type locality is Mountain Well, Churchill County.

Type is a female adult, skin and skull: #93520 United States National Museum, Biological Survey Collection. Collected by Harry C. Oberholser; original #101.

B. Subspecies Classification

Microdipodops pallidus ammophilus Hall

Microdipodops pallidus ammophilus Hall, 1941. Zool. Series, Field Mus. Nat. Hist., 27:273, December 8, 1941. Type from Railroad Valley, Able Springs, 12½ miles south of Lock's Ranch, 5000 feet, Nye Co., Nevada.

Microdipodops pallidus pallidus Merriam

Microdipodops pallidus Merriam, Proc. Biol. Soc. Washington, 14:147, July 19, 1901. Type from 10 miles east of Stillwater, near sink of Humbolt and Carson rivers, Churchill Co., Nevada. ;

Microdipodops pallidus pallidus, Hall, Zool. Series, Field Mus. Nat. Hist., 27:269, December 8, 1941.

Microdipodops megacephalus lucidus Goldman, Proc. Biol. Soc. Washington, 39:127, December 27, 1926. Type from 8 miles southeast Blair, 4500 feet, Esmeralda County, Nevada.

Microdipodops megacephalus dickeyi Goldman, Proc. Biol. Soc. Washington, 40:115, September 26, 1927. Type from 3 miles southeast Oasis, 5150 feet, Mono County, California.

Microdipodops pallidus purus Hall

Microdipodops pallidus purus Hall, Field Mus. Nat. Hist., Zool. Ser., 27:273, December 8, 1941. Type from 14½ miles south Groom Baldy, Lincoln County, Nevada.

Microdipodops pallidus ruficollaris Hall,

Microdipodops pallidus ruficollaris Hall, Proc. Biol. Soc. Washington, 54:60, May 20, 1941. Type from 5 miles southeast Kawich P O., Kawich Valley, 5400 feet., Nye Co., Nevada. Originally misspelled *Microdipodos*.

C. Subspecies Description and Distribution

Microdipodops pallidus ammophilus

Range-- Railroad Valley, Nye Co., Nevada

Diagnosis-- Upper parts are a light pinkish cinnamon color overlaid with a frosting of black. The color is of cinnamon color and barely evident, much less so than in ruficollaris from which ammophilus is further distinguished by the frosting of the back.

Microdipodops pallidus pallidus

Range-- Low western part of Nevada from southern Pershing county southward through Fish Lake Valley to Oasis, Mono Co., California; Deep Springs Valley, Inyo Co., California; and Eureka Valley, Inyo Co., California.

Diagnosis-- Size large; tail relatively long; color pale; nasals long. From M.p. ruficollaris this race differs in less reddish color of the upper parts, absence of the cinnamon-colored collar, longer tail, and longer nasals. Intergradation with M.p. ruficollairs is suggested by the redder than average color of specimens from Miller's Wells, Esmeralda Co., Nevada. There appears to be some geographic variation within the subspecies.

Microdipodops pallidus purus

Range-- Emigrant and Desert Valleys in easter Lincoln County, Nevada.

Diagnosis-- The palest, most nearly white of any of the subspecies. This is probably due to the fine, exceptionally white sand of the habitat. M.p. purus is characterized by the greater width across the maxillary processes of the zygomata and the reduced interorbital breadth.

Microdipodops pallidus ruficollaris

Range-- Fine sands of valleys from western Nye Co., eastward to western Lincoln county, Nevada.

Diagnosis-- Upper parts light pinkish cinnamon mixed with blackish, with a broad collar of more nearly cinnamon color. From M.p. purus this race differs in more reddish upper parts, presence of the cinnamon-colored collar, lesser maxillary breadth, and slightly less inflated auditory bullae. There appears to be very little variation between populations of the subspecies.

(After Hall, 1941)

D. General Species Description

The pale kangaroo mouse is pale pinkish cinnamon above with the hair of underparts white to the base, whereas M. megacephalus is brownish, blackish, or grayish above with underparts basally plumbeous and white-tipped. The upper parts of the tail are approximately the same color as upper body parts and lacking a black tip. The hind foot is slightly larger than that of M. megacephalus. The anterior palatine foramina are parallel-sided. The premaxillae extend well behind the nasals.

Total length	150 to 173 mm.	
Length of tail	74 to 99 mm.	
Length of hind foot	25 to 27 mm.	
Weight	10.3 to 16.8 grams	(Hall, 1941)

A comprehensive study by Hatt (1932) of the vertebral columns of ricochetal rodents gave information on the skeletal structures of M. megacephalus. These are characteristic of both species of Microdipodops: The neck is short, the cervical vertebrae are shorter than about 15% of the thoraco-lumbar length; the tail is long, vertebrae both lengthened and numberous; the anterior caudal vertebrae are short; a cervical neural spine occurs only on the axis and is narrow antero-posteriorly; the spines of the posterior lumbar region are long, narrow antero-posteriorly, and inclined forward; the spines over the sacrum are reduced or lost; the transverse process of the atlas is reduced.

Microdipodops pallidus has extremely large sebaceous glands, small mucous glands, and no sudoriforous glands in the oral lips and angle (Quay, 1965).

Hall (1946) noted a swelling in the proximal third or half of the tail, and Bartholomew and MacMillen (1961) believed that the swelling functioned as a fat storage depot in preparation for periods of torpor. Quay (1965) described this characteristic tail thickening as subcutaneous masses of large, unilocular fat cells. It probably does function to store fat, but O'Farrell (1973) found no seasonal variations in the size of the swelling when low plant productivity and drought conditions prevailed in M. megacephalus. Hall (1946) speculated that the tail served a probable function as a balancing organ aiding in bipedal locomotion.

Molt has been observed by Hall (1941) in kangaroo mice captured in May, June, and July. There appears to be but one molt per year.

There are no fossil accounts for this species.

III. Life History of Microdipodops pallidus, Merriam

A. Habitat

Upper Sonoran sagebrush desert with fine sand supporting some plant growth meets the requirements of this species. Fine sand without plants does not meet the requirements of this species (Hall and Linsdale, 1929).

Because the finest sand ordinarily occurs in the bottoms of valleys, as on the windward side of a playa, the mice are most abundant in the low parts of the valleys (Hall, 1946).

Vegetation is a kind which favors a zonal position lower than places supporting Artemisia tridentata. Atriplex and Sarcobatus are shrubs characteristic of the area in which kangaroo mice are found. Nowhere have Microdipodops been found at a place low enough zonally to support the cresote bush, Larrea (Hall, 1946).

Hall (1941) found that M. pallidus are always restricted to fine wind-blown sands.

Ghiselin (1970) found that there is random distribution on types of soils for M. pallidus where it is sympatric with M. megacephalus.

Fletcher (unpublished) has found that the soil found with kangaroo mice at Oasis and Deep Springs Valley consists of the following particle sizes: Less the 3% of the soil was gravel (2mm or larger), about 35% of the soil was coarse sand (.250 to 1mm), and that 60 to 65% of the soil was fine sand (.125mm and smaller).

B. Niche

Commonly found with Dipodomys deserti and D. merriami (Hall, 1946).

Among the more conspicuous plants in the same habitats in Fish Lake Valley as the kangaroo mouse were the following: Tetradymia comosa, Parosela polyadenia, Eurotia lanata, Oryzopsis hymenoides, Sarcobatus vermiculatus, and Gilia sp. (Hall and Linsdale, 1929).

C. Habits

1. Feeding

Nocturnal, often not coming out on brightly moon-lit nights (Hall, 1941)

Greatest activity shown in the first two hours after sunset with varied and diminishing activity for the remainder of the night (O'Farrell, 1974).

One captured mouse displayed a decided preferential choice for certain kinds of seeds. It selected certain grass seeds and ignored rolled oats. It seems reasonable to suppose that a similar preference for certain kinds of seeds might be exhibited in their natural surroundings. When offered a beetle the mouse readily took it and ate it. (Hall and Linsdale, 1929).

The cheek pouches of a specimen taken on June 7, 1931, 5½ miles north of Summit Spring, Lincoln Co., Nevada, contained twenty-three seeds of Oryzopsis hymenoides. In the next valley to the east, 8 miles southeast of Blair, W.B. Davis (MS) records that the contents of the cheek pouches of several of these mice comprised "two scarabaeid beetles, one small centipede, the pupa of a moth, and several kinds of seeds." Insects apparently make up considerable share of the food (Hall, 1946).

Various species of rodents differentially utilize seeds of different sizes according to their body sizes. For seeds below some critical size, it may simply require more energy to locate and harvest them than these seeds contain. It is apparent that the large kangaroo rats, D. deserti and D. ordi and the small pocket mouse, P. longimembris, use the smallest range of seed sizes, whereas species of intermediate size, M. pallidus, D. merriami, and perhaps P. maniculatus, show less tendency for specialization (Brown and Lieberman, 1972).

The saltatorial, largely bipedal species (Microdipodops and Dipodomys) tended to concentrate their foraging activities in the open areas away from the shrubs, whereas the scansorial, largely quadrupedal species foraged either in and adjacent to the clumps of vegetation (Perognathus and Reithrodontomys) or with equal intensity in all areas (Peromyscus), (Brown and Lieberman, 1972).

2. Water requirements

Microdipodops require no free water and obtain their water requirements either by the metabolic production of water as Dipodomys and/or from the moisture in their diet of seeds and insects.

One specimen of M. pallidus was kept in captivity for six months without any water to drink (Hall, 1941).

3. General Habits

Bartholomew and MacMillen (1961) found M. pallidus capable of both hibernation and estivation and determined that they showed no clearly defined zone of thermoneutrality, had a high critical temperature, and a tendency to hyperthermia at high temperatures rather than evaporative cooling.

Brown and Bartholomew (1969) reported that a low ambient temperature and reduced food supply induced torpor. They further found that periods of torpor were regulated in such a way that body weight was maintained while seed stores were conserved during both chronic and acute food shortages.

At high temperatures M. pallidus do not salivate or pant: they sprawled out flat on the sand with legs extended and lower jaw and neck prone on the substrate (Bartholomew and MacMillen, 1961).

In the absence of temperature stress, body temperature in M. pallidus averages 38.8° C. (Bartholomew and MacMillen, 1961).

Microdipodops pallidus has a pattern of torpidity which is intermediate between the prolonged periods of dormancy shown by hibernators such as marmots and ground squirrels and the daily torpor of temperate zone bats and a few small rodents such as Perognathus californicus (Brown and Bartholomew, 1969).

Samples of P. longimembris and M. pallidus became torpid daily for regular periods when maintained on a daily ration of .05 grams of mixed bird seed and held at an ambient temperature of 8° C.. The hemoglobin concentrations of these mice when aroused did not differ from those of animals of the same species on an ad libitum diet of bird seed at the same ambient temperature. Mean corpuscular hemoglobin concentration of M. pallidus per mean hematocrit for winter was 32.3, for summer 31.5, and 29.4 upon arousal from torpor (Lee and Brown, 1970).

Microdipodops pallidus utilizes a quadrupedal ricochet as its predominant form of locomotion. A bipedal ricochet is sometimes used. M. pallidus does not climb. The burrows are short and simple and are in or near wind-blown sand. Nest chambers within the burrows have not been found, and there is little tendency to build a nest in captivity. M. pallidus is relatively nonaggressive when compared with other Heteromyids. When attacked by another species, M. pallidus emits a scratchy, high pitched growl. Intraspecifically, however, this species is somewhat aggressive (Eisenberg, 1963).

Microdipodops pallidus during the day live below the ground in burrows which are closed to the outside by earth that the mice probably push into the opening; in any event, the wind soon after sunrise ordinarily drifts sand over the mouths of the burrows (Hall, 1941).

Tracks of M. pallidus are essentially miniatures of those of kangaroo rats. The relatively large impressions of the hind feet usually are not parallel but have the toes pointing outward. This position permits the hind feet, equipped as they are with stiff, projecting hairs on the sides of the soles, to function effectively in the sand when the animal leaps, which it does by using the two hind feet at the same time rather than alternately. Impressions of the forefeet usually are present, but if not, consecutive pairs of tracks left by the hind feet are farther apart than otherwise. This indicates that rapid progress is accomplished mainly or wholly by use of the hind feet. The mark ordinarily left by the dragging tail is absent under these circumstances; the tail is apparently carried higher off the ground when the animal makes haste (Hall, 1941).

Kangaroo mice are active at night on the surface at all seasons of the year, even when temperatures are 10° C. or more below freezing (Brown and Bartholomew, 1969).

"I do not know whether the mice come out in the snow. Each of the two species (M. megacephalus and M. pallidus) have been trapped on bare ground on nights so cold that their bodies were frozen in the morning. On nights when rain fell they seemed not to come out of their burrows; traps then caught but few kangaroo mice and sometimes none in places where they were known to be numerous (Hall, 1941).

The burrows of Microdipodops pallidus ranged in length from eight inches to nearly three feet, and in depth from four inches to two feet (Hall, 1941).

M. pallidus has remarkably shallow burrows, often no deeper than 4 inches (Hall, 1946).

The mouth of the burrow measured one inch vertically and three-fourths of an inch horizontally (Hall and Linsdale, 1929).

Hafner and Hafner (1975) reports that M. pallidus does have some swimming ability but it isn't as developed as that of M. megacephalus. "M. pallidus had a period of rapid, high intensity swimming followed by a period of lower intensity swimming. Individuals floated only occasionally and for brief periods." Individual M. pallidus had swimming times of 20 to 435 seconds before before submersion.

Feces measures three to four and one-half mm. in length and from one and one-half to two mm. in thickness. They are elliptical in lateral outline. They are of the same general shape as those of kangaroo rats (Hall and Linsdale, 1929).

D. Reproduction

1. Breeding season

Hall (1946) found pregnant females from March 29 to September 22.

Most of the young were born in May and June (Hall and Linsdale, 1929).

2. Age at first reproduction

unknown

3. Sex ratios

Unknown, however, for Microdipodops megacephalus O'Farrell (1973) found that in west-central Nevada the mice maintained a 2:1 ratio favoring males.

4. Age structure

Unknown, although the smallest young to be active above ground was a half-grown (weight 8.5 grams) female taken in Fish Lake Valley (Hall and Linsdale, 1929).

5. Litter size

Two to six with a mean of 3.9 (Hall, 1946).

6. Additional Reproductive Information

Embryos measured 22 mm. long from the tip of the nose to the tip of the tail without straightening the body (Hall and Linsdale, 1929).

Hall (1946) suggests that his data may show that there is more than one litter per year.

O'Farrell (1973) has found females with perforated vaginal orifices in April and again in July indicating two periods of estrus for M. megacephalus.

For M. megacephalus (O'Farrell, 1973) found that reproduction is negatively affected by a lack of fall and winter precipitation and consequent germination of winter annuals.

Only reproductive data available

E. Longevity

A captured M. pallidus was kept in captivity for 7 months by Hall and Linsdale (1929).

Egoscue et al (1970) maintained wild-trapped M. megacephalus in captivity for 5 years and 5 months.

F. Mortality Factors

1. Diseases

Diseases unknown but probably include diseases common to all mice.

Hall and Linsdale (1929) looked for lice or fleas on kangaroo mice without finding any. One specimen of M. megacephalus taken in Reese River Valley had a large tick, with abdomen distended, attached to the head between the ears. Another one of their specimens taken from the same locality lacked hair over most of its back.

2. Predation

Predation is probably the greatest mortality factor with coyotes, weasels, badgers, skunks, rattlesnakes, owls, and hawks being the natural enemies. Hall (1941) noted the high similarity of pelage coloration with that of the ground coloration. This would indicate M. pallidus is protected in some degree from natural enemies by protective coloration.

3. Man induced mortality

Man induced mortality is unknown but surely results in M. pallidus ending up as road kills and study skins. O'Farrell (personal comm.) has mentioned that some M. pallidus surely have died from radioactive leaks at the Nevada test site. However, the greatest danger to M. pallidus from man comes from his ability to alter the land. Burrows are shallow and can easily be crushed by heavy equipment. Hall and Linsdale (1929) concluded that M. pallidus seemingly do not thrive on cultivated land. Hence any conversion of desert valleys to farm land by use of irrigation will probably eliminate this species from the altered environment. Fletcher (unpublished) and Hafner (personal comm.) have attempted to trap M. megacephalus near

Halleck, Nevada where Hall (1941) captured many kangaroo mice, but were unable to do so because no suitable habitat could be found anymore due to the extensive agrarian development over the last thirty years. Fletcher (unpublished) has observed extensive soil trampling by cattle in Desert Valley, 22 miles west of Pioche, Lincoln Co., Nevada and found that the habitat is almost unsuitable for Microdipodops although a few specimens were captured there. More information is needed on the impact of cattle upon Microdipodops.

4. Environmental mortality factors

Environmental factors may account for some mortality in Microdipodops, but is presently unknown. O'Farrell (1973) reports for M. megacephalus that activity declined above and below the range, which varied with the seasonal temperature acclimation of the animals. Wind above 13 km per hour (8 m.p.h.) inhibited activity, probably due to blowing sand. Activity was highest under partly cloudy skies and ceased during rain. Seed production due to poor weather may be the greatest environmental mortality factor.

. Population Dynamics

A. Inter and Intraspecific Interactions

This species is relatively nonaggressive when compared with other Heteromyids. When attacked by another species M. pallidus emits a scratchy, high pitched growl. Intraspecifically, however, this species is somewhat aggressive (Eisenberg, 1963).

Brown and Lieberman (1972) found that three species in the 12-13 gram size range (M. pallidus, M. megacephalus, and P. penicillatus) "replaced" each other on different dunes in the Great Basin at 18 different localities, occupying approximately the same niche.

Hall and Linsdale (1929) reported that when several kangaroo mice were placed in a cage together they apparently paid no attention to one another. However, one that was kept for short periods of time with a small pocket mouse (Perognathus nevadensis) bit the pocket mouse on the head and back.

Blaustein (1974) has shown that the greater abundance of Microdipodops in September and October than in nay other month is due to the fact that the Perognathus longimembris are pugnaceous and that they restrict the activity of Microdipodops when both species are active.

Fletcher (unpublished) has had a M. pallidus and P. longimembris in the same gallon jar and the P. longimembris actively attacked the M. pallidus repeatedly.

Competition with ants for surface seeds may exist but has yet to be shown for M. pallidus.

B. Seasons of Activity

Greatest activity is September and October (Blaustein, 1974).

Some Winter activity was found by Hall (1946).

O'Farrell (1973) speculated with M. megacephalus that P. longimembris inhibited the movements and activity of M. megacephalus. It was suggested that during the summer when these pocket mice (P. longimembris) were at peak activity, M. megacephalus probably shifted from a granivorous to an insectivorous feeding strategy. In addition, these species maintained a constant spatial isolation of centers of activity.

Active March through October with some winter activity and some hibernation.

C. Movements and Homerange

Ghiselin (1969) reported on the movements of this species and gave maximum distance between captures of 240 meters for males and 136 meters for females.

Hall and Linsdale (1929) reported that the home range appears to be extensive for so small an animal. As shown by tracks at Halleck, Nevada, the home range, in one case at least for M. megacephalus extended seventy yards.

O'Farrell (1973) noted for M. megacephalus a high degree of fidelity to a given locus. He further determined that a small territory was maintained around the burrow and a relatively large home range was utilized that overlapped considerably with the home range of conspecifics. Seasonal changes in size of home range were noted. The mean yearly circular home range value for males was 6613 square meters, and for females 3932 square meters. No quantitative information is available for M. pallidus.

V. Economic Value

"Of all the mammals of the Great Basin region, probably none is of less economic importance, or of less potential economic importance, than the kangaroo mice. They live largely on seeds and constitute no benefical or detrimental factor appreciable to us on range land." (Hall and Linsdale, 1929).

Appendex I -- Additional niche information

Subsequent to writing the text of the annotated bibliography on the pale kangaroo mouse, Microdipodops pallidus presented earlier I have obtained the following information:

Lee and Brown (1970) report the following rodents captured along with Microdipodops pallidus 13 miles north of Dyer, Fish Lake Valley, 5000ft. , Esmeralda County, Nevada.

Ammospermophilus leucurus
Dipodomys merriami
Dipodomys deserti
Neotoma lepida
Peromyscus maniculatus
Perognathus longimembris

Appendex II -- Appendex of museums contacted in finding localites of Microdipodops pallidus in California and Nevada.

Museums visited and specimens examined first hand:

1. California State University at Fullerton. Private collection of approximately 160 Microdipodops collected by D. Fletcher. To be deposited in the future at L.A.C.M.

2. University of Kansas at Lawrence, Kansas. Approximately 15 specimens of M. pallidus and 50 specimens of M. megacephalus.

3. Los Angeles County Museum of Natural History. Approximately 45 specimens of M. pallidus and 40 specimens of M. megacephalus.

4. Museum of Vertebrate Zoology, University of California at Berkley. Approximately 500 speciems of M. pallidus and 1200 specimens of M. megacephalus.

5. Texas Tech. University at Lubbock, Texas. Approximately 50 specimens of M. pallidus and 200 specimens of M. megacephalus.

6. University of Montana at Missoula, Montana. Only 5 specimens of M. megacephalus.

7. University of Nevada at Las Vegas, Nevada. Approximately 50 specimens of M. megacephalus and 120 specimens of M. pallidus (many of which are unsexed and needing cleaning).

8. United States National Museum, Washington D.C.. Approximately 40 specimens of M. pallidus and 100 specimens of M. megacephalus.

9. University of Utah at Salt Lake City, Utah. Approximately 10 specimens of M. pallidus and 50 specimens of M. megacephalus.

Museums Called by Telephone:

1. California State University at Long Beach. A few specimens of M. megacephalus and 30 or so specimens of M. pallidus, of which includes specimens of M. pallidus from Eureka Valley, California.

Museums that Could Provide Potential Information and Should Be Contacted:

1. University of California at Los Angeles.

2. University of Michigan at Ann Arbor.

3. University of Nevada at Reno.

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